Compressibility Parameters in Assessing the Collapse Potential of Red Soils in Visakhapatnam Region

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Abstract *— Soils of Visakhapatnam region is located by red soil found in warm temperature, moist and deciduous weather and not capable of retaining moisture. These soils are red in colour due to high iron content and also show relatively high strength in dry state. Several methods have been studied on the degree of collapsibility by measuring collapsible potential. In the present study the volume changes are determined by conducting single oedometer test on compacted soils and their collapsible potential is classified as per Jennings and Knight (1975), ASTM D5333.*

Keywords **—** Degree of collapsibility, single oedometer test, collapsible potential,

I. INTRODUCTION

Collapsible behavior of red soils can be considered as critical issue for geotechnical engineers in understanding challenges when structure founded on these soils subjected to large differential settlements which increase the cost of repairs and rehabilitation.

Exciting methods of Estimation of collapse potential:

1. Jennings and Knight (1975):

Jennings and knight describes the procedure for the single oedometer test to measure the collapse potential of soils.

Collapse Potential $C_P = (\Delta H/H)$

$C_P = 0 – 1\%$ →No Problem,
$C_P = 1 – 5\%$ →Moderate Trouble,
$C_P = 5 – 10\%$ →Trouble,
$C_P = 10 – 20\%$ →Severe trouble,
$C_P = 0 – 1\%$ →Very severe trouble.

2. ASTM D5333:

ASTM D5333 describes the procedure for the collapse potential (I_e), which is the wetting induced strain measured at a reference stress level of 200 kPa. Based on the value of the value of the collapse index, the degree of specimen collapse (or collapse potential) can be classified as:

Collapse potential $I_e = \Delta e/(1+e_o)$.

$I_e \leq 0$ → Free from collapse
$I_e = 0.1$ to 2 → Slight Collapse
$I_e = 2.1$ to 6 → Moderate
$I_e = 6.1$ to 10 → Moderate to Severe
$I_e > 10$ → Severe

Collapsible soils are quite extensive though identifications and characterization is not that simple. A more general approach may require assessing the collapsible potential.

II. MATERIALS

To study the geotechnical characterization and single oedometer of red soils in Visakhapatnam region, the soil samples were collected at a depth of 1.0 – 1.5 m from the ground level and the collected samples were dried and subjected for the strength tests as per IS code.

III. TESTS & RESULTS

To explain collapse potential of red soils, Ten number of SM nature with varying composition subjected to remoulded conditions to their corresponding bulk density, dry densities, water content, void ratio, there collapse potential from Jennings and knight and ASTM D5333.

TABLE 1: PROPERTIES OF RED SOILS IN VISAKHAPATNAM REGION

Location/Property	SM-I	SM-II	SM-III	SM-IV	SM-V	SM-VI	SM-VII	SM-VIII	SM-IX	SM-X
Gradation Properties										
Gravel (%)	0	0	0	0	0	0	0	0	0	0
Sand (%)	85	80	76	82	74	78	76	75	80	82
Fines (%)	15	20	24	18	26	22	24	25	20	18

Silt (%)	15	17	20	16	21	19	20	19	14	14
Clay (%)	0	3	4	2	5	3	4	5	6	4
Specific Gravity	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.65	2.66	2.65
Index Properties										
Liquid Limit (%)	21	22	23	22	21	22	22	21.50	23.5	22
Plastic Limit (%)	18	18	19	18	17	19	18	17.50	19.5	18.50
Plasticity Index (I_p)	3	4	4	4	4	3	4	4	4	3.50
IS Classification	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM
Compaction Characteristics										
OMC (%)	9.00	9.20	9.40	9.00	8.80	9.30	9.20	9.00	9.50	9.10
MDD (g/cc)	1.75	1.74	1.77	1.75	1.68	1.72	1.73	1.70	1.76	1.71
Bulk Density (g/cc)	1.54 to 1.90	1.56 to 1.90	1.55 to 1.94	1.54 to 1.91	1.50 to 1.83	1.53 to 1.88	1.54 to 1.89	1.48 to 1.85	1.53 to 1.93	1.52 to 1.86
Dry Density (g/cc)	1.49 to 1.75	1.51 to 1.74	1.50 to 1.77	1.50 to 1.75	1.45 to 1.68	1.48 to 1.72	1.48 to 1.73	1.44 to 1.70	1.47 to 1.76	1.48 to 1.71
Water Content (W_n)	3.20 to 9.00	3.60 to 9.20	3.20 to 9.40	3.00 to 9.00	3.20 to 8.80	3.40 to 9.30	3.80 to 9.20	3.00 to 9.00	4.00 to 9.50	2.90 to 9.10
Void ratio	0.78 to 0.52	0.76 to 0.52	0.77 to 0.50	0.77 to 0.51	0.83 to 0.58	0.79 to 0.54	0.79 to 0.53	0.84 to 0.55	0.81 to 0.51	0.79 to 0.54

- Grain size distribution of red soils are dominated by sand particles of 74 – 85%, fines of 15 – 26%, out of which silt particles are 14 – 21% and clay particles are 0 – 6%.
- These soils have liquid limit in the range of 21% - 23.5%, plasticity index in the range of 3-4. As per I.S 1498-1970 these are classified under SM Soil.
- Red soils can attain high density and bearing values at optimum moisture content can be effectively used in civil engineering constructions.

A. PARAMETERS CONSIDERED IN EXPLAINING COLLAPSIBLE POTENTIAL:

To explain the collapse potential (C_P) of red soil in Vishakhapatnam region of SM nature by considering the parameters mentioned above at their remoulded conditions are shown in below. Ten number of red soils of SM group were considered and their corresponding, compression (settlement), percentage volume decrease and collapse potential are grouped and are shown below.

Table: 2 Variation of Compression with dry density

Υ_d (g/cc) →	1.4 – 1.5	1.5 – 1.6	1.6 – 1.7	1.7 – 1.8
Soils ↓	**Compression ΔH** ↓			
SM - I	0.20	0.18	0.09	0.02
SM - II	0.20	0.13	0.04	0.01
SM - III	0.22	0.18	0.07	0.01
SM - IV	0.23	0.19	0.04	0.00
SM - V	0.25	0.13	0.03	0.00
SM - VI	0.19	0.10	0.04	0.01
SM - VII	0.19	0.08	0.03	0.01
SM - VIII	0.24	0.13	0.04	0.01
SM - IX	0.23	0.15	0.04	0.01
SM - X	0.21	0.13	0.04	0.01
Range	0.19 – 0.24	0.08 – 0.19	0.03 – 0.09	0.00 – 0.02

Table: 2 Variation of Percentage volume decrease with dry density

Υ_d (g/cc) →	1.4 – 1.5	1.5 – 1.6	1.6 – 1.7	1.7 – 1.8
Soils ↓	Percentage Volume Decrease ↓			
SM - I	10.00	9.00	4.50	1.00
SM - II	10.00	6.50	2.00	0.50
SM - III	11.00	9.00	3.50	0.00
SM - IV	11.50	9.50	2.00	0.00
SM - V	12.50	6.50	1.00	0.50
SM - VI	9.50	5.00	2.00	0.50
SM - VII	9.50	4.00	1.50	0.50
SM - VIII	12.00	6.50	2.00	0.50
SM - IX	11.50	7.50	2.00	0.50
SM - X	10.50	6.50	2.00	0.50
Range	9.50-12.50	4.00-9.50	1.00-4.50	0.00-1.00

Table: 2 Variation of Collapse Potential with dry density

Υ_d (g/cc) →	1.4 – 1.5	1.5 – 1.6	1.6 – 1.7	1.7 – 1.8
Soils ↓	Collapse Potential ↓			
SM - I	9.00	7.40	3.50	0.66
SM - II	8.90	6.02	1.28	0.66
SM - III	12.50	8.23	3.10	0.67
SM - IV	10.73	8.72	1.28	0.66
SM - V	10.90	5.32	2.08	0.63
SM - VI	8.40	4.14	1.25	0.65
SM - VII	8.40	3.60	1.25	0.65
SM - VIII	12.00	5.30	2.00	0.50
SM - IX	10.50	7.10	1.30	0.66
SM - X	9.50	5.30	1.30	0.65
Range	8.40-12.50	3.60-8.72	1.28-3.50	0.50-0.67

B. COMPARISON OF SINGLE OEDOMETER TEST RESULTS:

Based on the test results of single oedometer test conducted on red soils compacted at varies dry densities as per ASTM D5333 the following identifications are made.

a) Soils compacted at densities in between 1.4g/cc – 1.5g/cc:

Red soils of SM nature compacted at dry densities of (1.4-1.5g/cc) exhibited the compression (settlements)in the range of 0.19-0.24 and percentage volume decrease in the range of 9.50-12.50. At these dry densities the Jennings and Knight (Cp) is in the range of 8.40-12.50, which is in between 5-20% classified under severe trouble to trouble, similarly as per ASTM D5333 these are greater than 10%, and classified under moderately severe too severe.

b) Soils compacted at densities in between 1.5g/cc – 1.6g/cc:

Red soils of SM nature compacted at dry densities (1.5-1.6 g/cc) exhibited the compression (settlement)in the range of 0.08-0.19and percentage volume decrease in the range of 4.00-9.50. At these dry densities the Jennings and Knight (Cp) is in the range of 3.60-8.72, which is in between 1-10% classified under moderate trouble to trouble, similarly as per ASTM D5333 which are in the range of 2.1-10%, and classified under moderate collapse to moderately severe.

c) Soils compacted at densities in between 1.6g/cc – 1.7g/cc:

Red soils of SM nature compacted at dry densities (1.6-1.7 g/cc) exhibited the compression (settlement)in the range of 0.03-0.09and percentage volume decrease in the range of 1.00-4.50. At these dry densities the Jennings and Knight (Cp) is in the range of 1.28-3.50, which is in between 1-10% classified under moderate trouble to trouble, similarly ASTM D5333 which are in the range of 2.1-10%, and

classified under moderate collapse to moderately severe.

d) Soils compacted at densities in between 1.7g/cc – 1.8g/cc:

Red soils of SM nature compacted at dry densities (1.7-1.8 g/cc) exhibited the compression (settlement) in the range of 0.00-0.02and percentage volume decrease in the range of 0.00-1.00. At these dry densities the Jennings and Knight (Cp) is in the range of 0.50-0.67,which is in between 0-1% classified under no problem, similarly ASTM D5333 which are in the range of 0.1 -2 %, and classified under slight collapse.

IV. CONCLUSION

1. Red soils compacted at dry densities in the range of 1.4-1.5 g/cc exhibited high collapse potential under saturated condition.
2. Red soils compacted at dry densities nearing to MDD exhibited low collapse potential, dry densities between dry to maximum dry density conditions exhibited moderate state of collapse behavior.
3. Jennings and Knight (1975), ASTM D5333, have the same trends in assessing the collapse potential of red soils.

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